# 19. Modelling the Management of Systems Engineering Projects

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**Aerospace Concepts**

## Abstract

As described in the *INCOSE Systems Engineering Handbook*[18], systems engineering is an interdisciplinary, holistic approach to realise successful systems. It often involves a combined effort of a team of professionals from different disciplines and backgrounds.

The primary role of the Systems Engineering Manager (SEM) of a complex project is to ensure that the technical conduct of the project and the technical products achieve the required quality. The SEM performs this role by defining the technical processes, documentation and output products within the engineering lifecycle of a project through systems engineering management. These aspects of a project are not brought together through any other single management process. Furthermore, systems engineering management supports the other business systems such as project management, engineering management and quality management.

Particularly in early concept development phases of a project, it is important for those involved in Model-Based Systems Engineering (MBSE) to not lose sight of systems engineering management as an enabler of engineering rigour. Engineers can overlook systems engineering management amongst the MBSE methods and technical activities they are conducting.

In his paper at the 2004 INCOSE International Symposium[19], Eric Honour concludes that systems engineering effort improves development quality, cost and schedule compliance, and that systems engineering management is known to be an important part of the systems engineering process. Further to this, improved quality of the systems engineering activity increases these benefits.

The key document used to guide all technical aspects of the project is the Systems Engineering Management Plan (SEMP). The SEMP is now often referred to as a Systems Engineering Plan (SEP), and defines systems engineering organisation, process and products, and also describes speciality engineering integration in a project[20].

A SEMP is an evolving document that captures a project's current systems engineering strategy and its relationship with the overall project management effort. The purpose of the SEMP is to describe the detailed operational plan for executing systems engineering. It also describes how a project organisation will manage technical activities in accordance with

[18] Haskins, C., ed. 2010 *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities.* Version 3.2. Revised by M. Krueger, D. Walden, and R. D. Hamelin. San Diego: INCOSE

[19] Honour, E., *Reducing Longterm System Cost by Expanding the Role of the Systems Engineer,* INCOSE International Symposium, France, June 2004.

[20] IEEE, *IEEE Standard for Application and Management of the Systems Engineering Process*, Institute of Electrical and Electronics Engineers 1220-2005, 09 Sept 2005

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| 1. REPORT DATE | 2. REPORT TYPE | 3. DATES COVERED |
|---|---|---|
| **FEB 2013** | **N/A** | **-** |

| 4. TITLE AND SUBTITLE | 5a. CONTRACT NUMBER |
|---|---|
| **Modelling the Management of Systems Engineering Projects** | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Aerospace Concepts** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release, distribution unlimited**

13. SUPPLEMENTARY NOTES
**See also ADA585222. Proceedings of the 2012 Model-Based Systems Engineering Symposium, 27 - 28 November 2012, DSTO Edinburgh, South Australia., The original document contains color images.**

14. ABSTRACT
**As described in the INCOSE Systems Engineering Handbook18, systems engineering is an interdisciplinary, holistic approach to realise successful systems. It often involves a combined effort of a team of professionals from different disciplines and backgrounds. The primary role of the Systems Engineering Manager (SEM) of a complex project is to ensure that the technical conduct of the project and the technical products achieve the required quality. The SEM performs this role by defining the technical processes, documentation and output products within the engineering lifecycle of a project through systems engineering management. These aspects of a project are not brought together through any other single management process. Furthermore, systems engineering management supports the other business systems such as project management, engineering management and quality management.**

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | |
| **unclassified** | **unclassified** | **unclassified** | **SAR** | **12** | |

partners, clients and contractors. All other engineering control documents, such as the Test and Evaluation Master Plan, Configuration Management Plan and Risk Management Plan, are subordinate to the SEMP and must be consistent with it[21]. The SEMP should be established early in the project and updated as necessary to ensure its effectiveness.

This presentation will outline an example of how a model-based systems engineering approach can be taken to represent the systems engineering management aspects of a project, and how the resulting engineering management model can be interrogated to produce the outputs required for a quality SEMP. After describing the underlying structure of the systems engineering management model, an example will demonstrate its use, with a focus on activities taking place in Concept Engineering phases of a project.

This modelling of the project from the point of view of the SEM provides the benefits inherent in the application of MBSE; consistency, traceability, reuse and information sharing. Further to the benefits inherent in the MBSE method, benefits can be gained by facilitating the interface between the management system model and the various engineering models of the project.

Engineering Management plan has a number of benefits that can improve product cost, schedule and quality when used appropriately. By having an approach tailored to the project, and interfacing this in a useful way, the likelihood of its use and the benefits of this use greatly increase.

A robust, complete and consistent SEMP provides clear and unambiguous guidance to systems engineers and technical staff, improves efficiency of the project effort and likelihood of project success. Using a model-based approach to systems engineering management, particularly in a model-based development environment closely couples the systems engineering process and product, allowing clear definition of responsibilities and improved ability for assurance that these responsibilities have been carried out.

## Presenter Biographies

**Daniel Spencer** works as a systems engineer for Aerospace Concepts Pty Ltd. He has over a decade of experience in design and development of systems solutions across a broad range of industries, both in Australia and the United Kingdom. Dan holds a Bachelor of Engineering in Information Technology and Telecommunications from the University of Adelaide. He has been working with Australian Defence clients developing and refining tools and methods for a repeatable and comprehensive MBSE method, while using this approach for real-world capability definition and development projects.

**Shaun Wilson** is the Chief Executive Officer of aerospace and systems engineering house, Aerospace Concepts Pty Ltd. He is a practising systems engineer with particular expertise in aerospace modelling and simulation and conceptual design. His experience spans from aerospace and defence to mining and leisure sports. Shaun sits on a range of company boards, holds multiple degrees, and is a published in several technical fields.

[21] NASA, *Systems Engineering Handbook*, Revision 1, December 2007.

**Presentation**

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# Modelling the Management of Systems Engineering Projects

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## Outline

- Systems Engineering Management
- Aims of the Systems Engineering Management Model
- Modelling of Systems Engineering Processes and Management
- The SEMP as Output from the Model
- Architecture of the Model
- Example
- Benefits

## Systems Engineering Management Introduction

- NASA Systems Engineering Handbook:

  *"Systems engineering management is a technical function and discipline that ensures that systems engineering and all other technical functions are properly applied."*

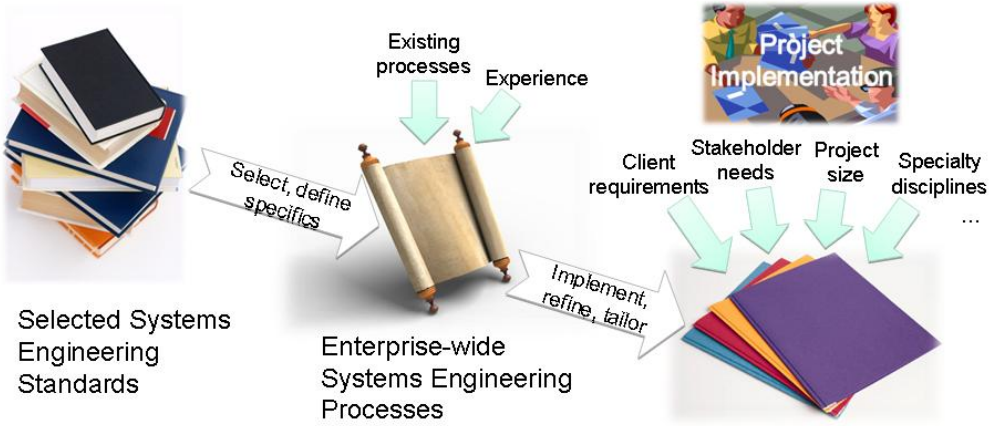
- The goal of the Management Process is to organise the technical effort in the project lifecycle



## Aims of the Systems Engineering Management Model

- Provide a template of the Systems Engineering Processes, Controls and Plans
- Implement this as model of Project Management aspects
  - Specifically concentrating on Systems Engineering Management
  - Linked through MBSE tool to the System and Operational models
- Output SEMP from model
  - Reduce effort and possibilities of inconsistencies when tailoring a SEMP

# Implementing Systems Engineering Processes




Selected Systems Engineering Standards

*eg:*
*IEEE Std 1220-2005*
*ISO/IEC 15288*

Enterprise-wide Systems Engineering Processes

*"The way things are done around here"*

•May include template for a SEMP

Project-specific Systems Engineering Management Plan and subordinate plans



# Modelling Systems Engineering Processes

- A template is made to be modified for implementation
- Key is linking of data together in the model – a change in one place reflects in others
- Have an Enterprise-wide Systems Engineering Process Model
- Instantiate this model for each project, refining, tailoring and extending as required

## Modelling Systems Engineering Management

- The SE Management Model is:
  - A representation of the systems engineering processes and structure
  - Built within a software tool (we have chosen Vitech's CORE, with it's Program Management modules)



## The SEMP as Output from the Model

A *Systems Engineering Management Plan (SEMP)* is the key document used to guide all technical aspects of the project

- It defines SE organisation, process, products, and speciality engineering integration
- An evolving document capturing current SE strategy and relationship with overall Project Management effort

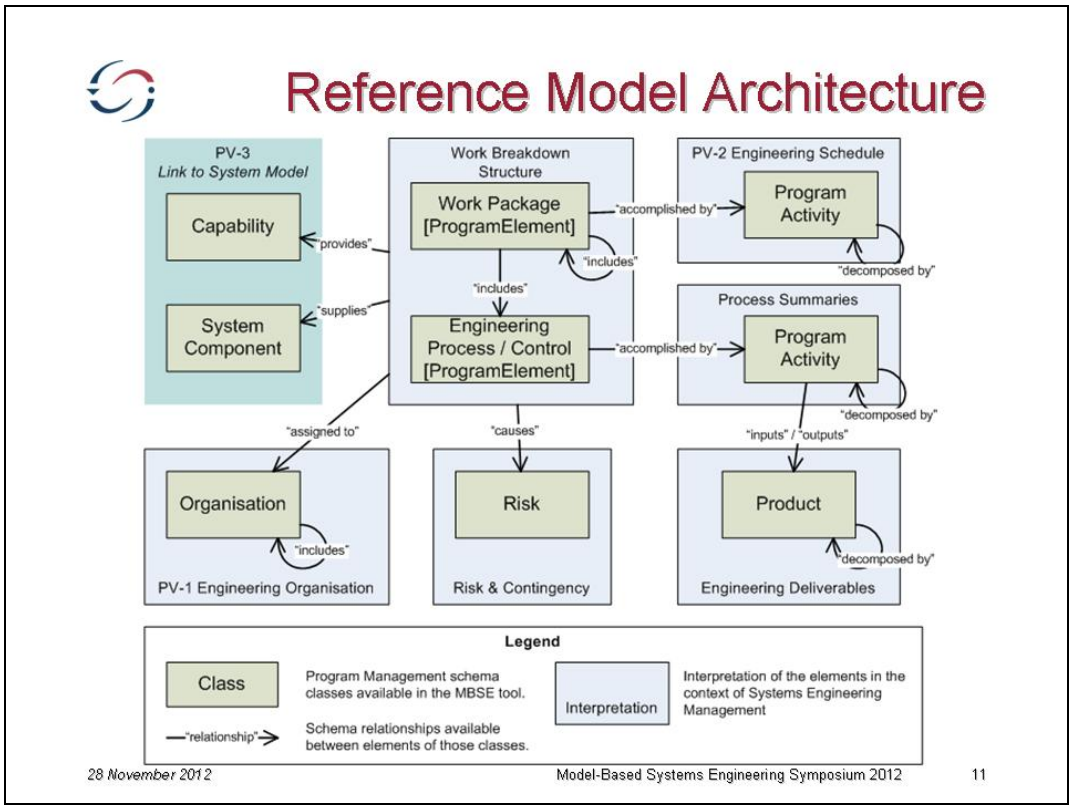
# DoDAF 2.0 Project Viewpoints

- PV-1: Project Portfolio Relationships
  - Represents an organisational perspective on the project
- PV-2: Project Timelines
  - Can be Gantt chart view of the project, including dependencies
- PV-3: Project to Capability Mapping
  - Maps project to capability, showing how elements help to achieve a capability
  - Analogous to SV-5a (Operational Activity to System Function Traceability Matrix)
- UPDM provides a standardised way for representing these viewpoints



# SEMP Viewpoints on the Model

- Work Breakdown Structure
  - Hierarchy of all work packages for the project
  - *Systems Eng Processes and Controls are a part of this WBS*
- Descriptions of each Systems Engineering Process and Control
  - Process and Control descriptions
  - Activity models allowing Flow-Block Diagram outputs
  - Responsibilities linking to Engineering Organisations
- Implementations of the three DoDAF 2.0 Project Viewpoints
  - PV-1 to describe the Engineering Organisations, including:
    - Engineering authority and delegation of responsibility
    - Defined relationships with subcontractors, suppliers etc
  - PV-2 to bring all work packages together in an Engineering Schedule
    - *via higher-level activity model for the overall project*
  - PV-3 to map Activities to Engineering Deliverables and Capabilities


Reference Model Architecture
PV-3
Link to System Model
Capability
System Component
"provides"
"supplies"
Work Breakdown Structure
Work Package [ProgramElement]
"includes"
Engineering Process / Control [ProgramElement]
"accomplished by"
PV-2 Engineering Schedule
Program Activity
"decomposed by"
Process Summaries
"assigned to"
"causes"
"inputs" / "outputs"
Organisation
PV-1 Engineering Organisation
Risk
Risk & Contingency
Product
Engineering Deliverables
Legend
Class
Program Management schema classes available in the MBSE tool.
"relationship"
Schema relationships available between elements of those classes.
Interpretation
Interpretation of the elements in the context of Systems Engineering Management
28 November 2012
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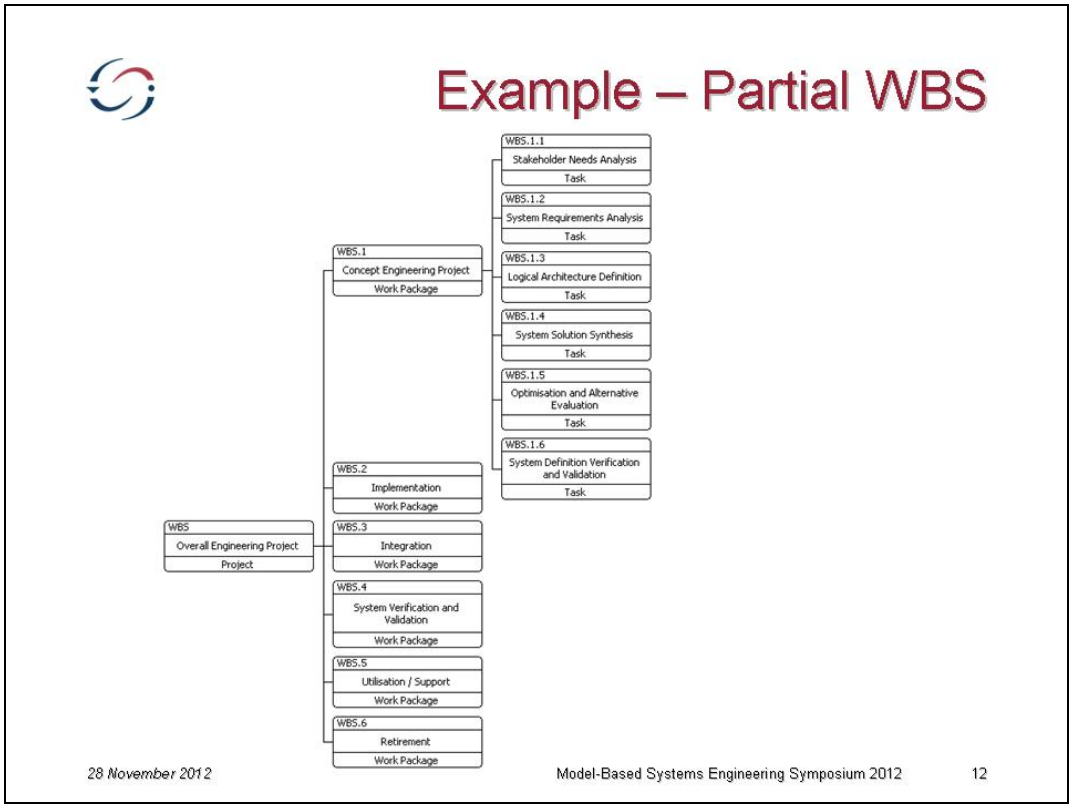
Example – Partial WBS
WBS
Overall Engineering Project
Project
WBS.1
Concept Engineering Project
Work Package
WBS.2
Implementation
Work Package
WBS.3
Integration
Work Package
WBS.4
System Verification and Validation
Work Package
WBS.5
Utilisation / Support
Work Package
WBS.6
Retirement
Work Package
WBS.1.1
Stakeholder Needs Analysis
Task
WBS.1.2
System Requirements Analysis
Task
WBS.1.3
Logical Architecture Definition
Task
WBS.1.4
System Solution Synthesis
Task
WBS.1.5
Optimisation and Alternative Evaluation
Task
WBS.1.6
System Definition Verification and Validation
Task
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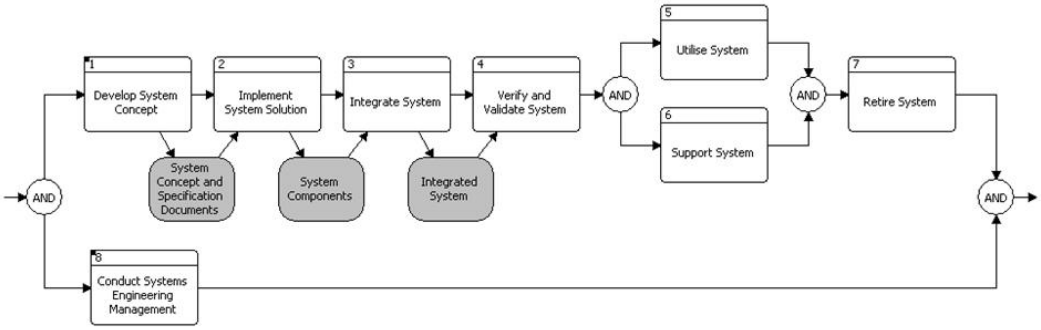
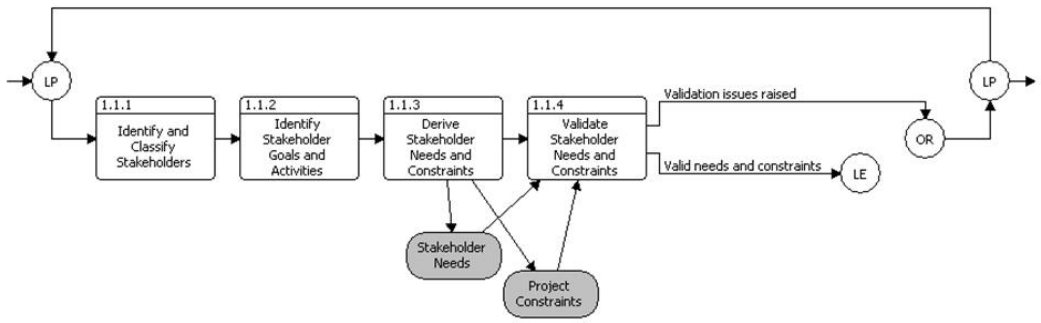
# Example – Overall Engineering Activity Model



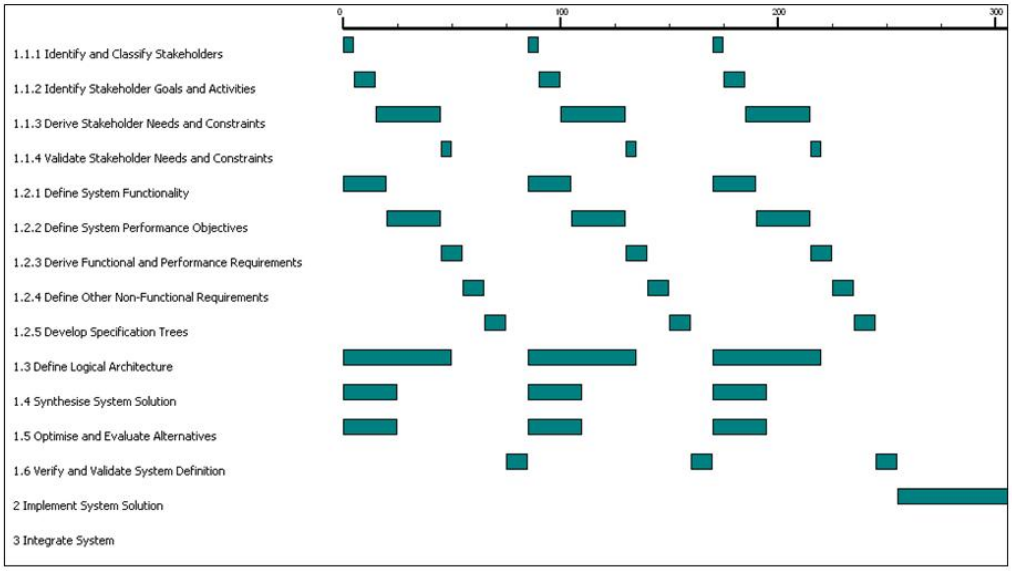



# Example – Process Summary Activity Model

- Analyse Stakeholder Needs activity



# Example – Engineering Schedule






# The Alternative

- Document-based approach to developing a SEMP
  - Systems Engineering approach not linked to WBS or master schedule
  - Responsibilities not linked to project organisation
  - System Engineering tasks not linked to capability
- In the alternative approach, changes made to these aspects of the SEMP need to be made in multiple places

## Benefits of the Modelling Approach

- Common benefits of MBSE approach:
  - Consistency
  - Traceability
  - Reuse
  - Information sharing
- Interfacing models through an MBSE tool
  - Between Management Model and various engineering and technical models
  - Clearly define responsibilities
  - Improve abilities for assurance on these responsibilities
- Produce a more robust, complete and consistent SEMP



## Benefits of a robust SEMP

- Provide clear, unambiguous guidance to technical staff
- Improve efficiency of project effort
- Improve capability quality, cost and schedule

***The bottom line***

- Improve likelihood of project success

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# Questions?

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